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AN ULTRASONIC TRANSLATOR

By

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April 1965

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ABSTRACT

(An ultrasonic receiver is discussed which amplifies and translates ultrasonic signals to the audible region.) This ultrasonic receiver is transistorized and light weight. In addition to surveillance, an application of this device is proposed for short range silent-signalling.

FOREWORD

The work described was conducted as part of U.S. Army Limited War Laboratory Task 07-P-63.

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INTRODUCTION

The use of ultrasonics is becoming common place today what with the uses of it for submarine navigation and detection, remote control of TV sets, burglar alarms and even the dispersing of pigeons from public and private buildings.

The ultrasound region starts just above the upper limit of human hearing which is approximately 20,000 cycles per second. The ultrasound band of 20,000 to 100,000 cycles per second is of interest here.

The range of ultrasound is limited. All things being equal, amplitude varies as the inverse square of frequency. Increasing the power of an ultrasound generator source will increase the received amplitude up to the point where the atmospheric viscous, and other non-linear effects produce severe losses, overcoming the gain of increased power. Within its short range, however, ultrasound could prove to be very useful in some limited war situations.

In general most sounds, whether natural or man-made, consist of audible and supersonic components. It is rare to have a source generate dominantly ultrasound. But in cases where a person is moving stealthily, so as not to be normally heard, there exists the possibility of using an ultrasonic receiver to detect his movements. Such sounds as those produced by rubbing one's hand over clothing, walking over grass, brushing of shoes and pants against grass and bushes may be detectable supersonically at a greater distance than by means of the unaided ear. This can be so, particularly in dynamic situations, where the ambient audible background sound level is high enough to provide "masking" of intrusion and stealth-like activities. Here an ultrasonic listening device coupled to the listener by means of headphones, which exclude the masking audible backgrounds, could be applicable and useful.

The item described here is an ultrasonic receiver which is tuned to a band of acoustic energy between 26 to 28 kilocycles.

I. DESCRIPTION OF APPARATUS

The ultrasonic translator is a small, battery operated, light weight, self-contained device. Its function is to "listen" to an ultrasonic-acoustic region and translate or convert this region to audible sounds which an operator can hear via headphones.

The 26 to 28 KC region was chosen because of the availability of commercial transducers in this range. Since the received amplitude of ultrasonic signals varies as the inverse square of frequency, the lower the center frequency used the higher the sensitivity which can be attained.

The complete circuit schematic is shown in Fig. 1.

Fig. 2 is an external view of the complete receiver and Fig. 3 is an internal view.

Preliminary tests showed that with the ultrasonic translator footsteps on grass could be heard at distances up to 50 feet. Future tests will establish the range of utility of this device in varying environmental situations.

An unusual application for the ultrasonic translator is in the area of short range silent signalling. A small, simple ultrasonic sender or transmitter, coupled with the receiver, can be used for secure, coded, communication even through heavy brush. Another possible application for this combination would be for night time, limited visibility, guidance or "follow the leader" tactics through heavy vegetation. An ultrasonic transmitter was designed and fabricated. The schematic for this is shown in Fig. 4. The same type transducer used in the receiver was used in the transmitter. Q_1 is a very low powered oscillator driving Q_2, which converts the low level signal at its base to a high voltage drive to the transducer. Tests showed the impedance of the transducer to be about 12,000 ohms. The voltage applied to the transducer is about 70 volts peak to peak. The push button switch used to key the ultrasonic transmitter actually applies battery power to the circuit. Therefore, no power at all is consumed in stand-by, so battery life should approach shelf-life if the device is used intermittently.

Initial, rough trials with the transmitter-receiver combination produced the following data:

a. In open terrain: detection of the transmitter signal was attained at ranges up to 100 yards.

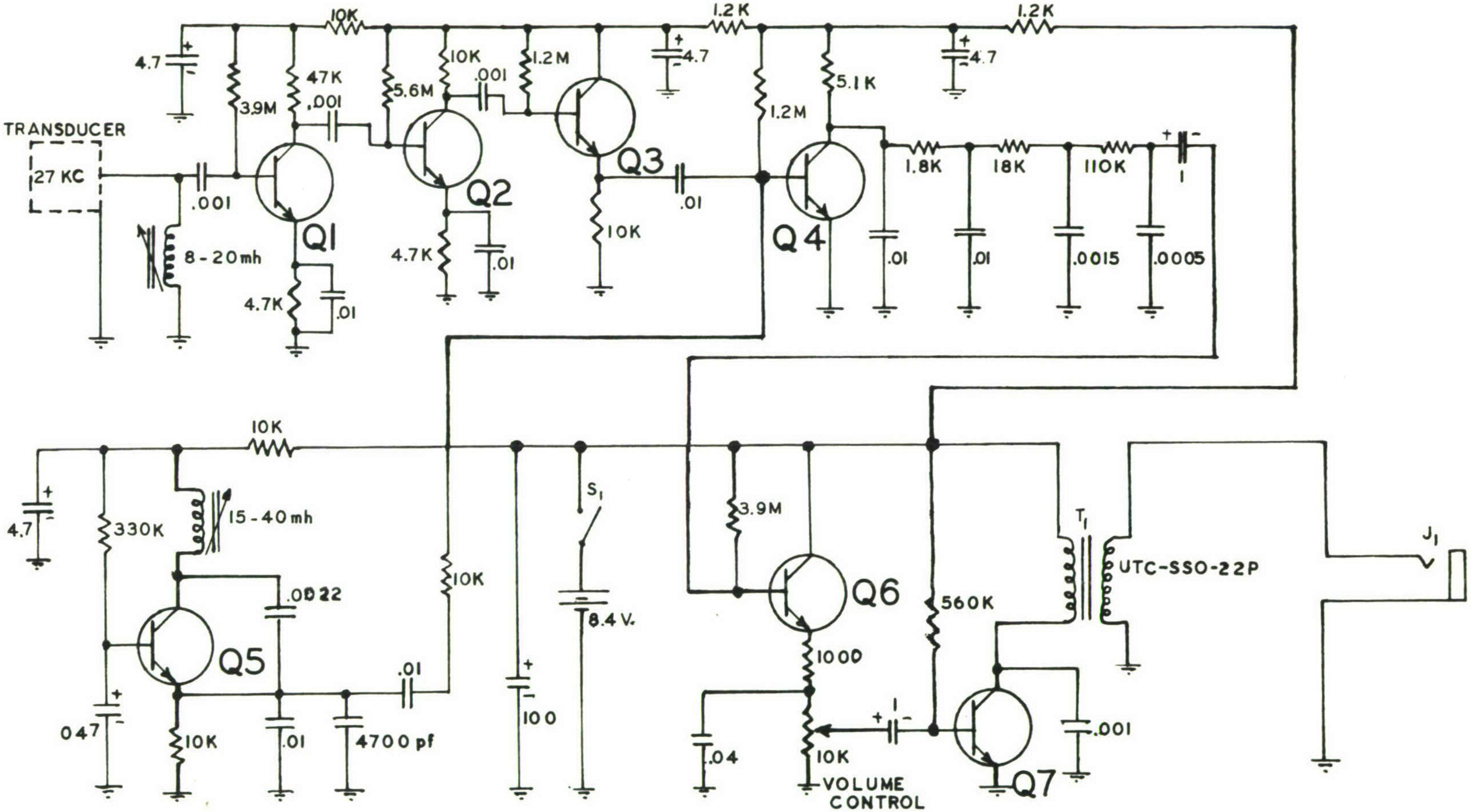


Figure 1

ULTRASONIC RECEIVER

NOTES

1. ALL RESISTOR VALUES IN OHMS
2. ALL CAPACITOR VALUES IN MICROFARADS
3. K = 1,000
4. M = 1,000,000
5. PF = PICOFARADS
6. mh = MILLIHENRIES
7. Q1, Q2, Q4, & Q6 ARE TYPE 2N2712
8. Q3 & Q5 ARE TYPE 2N2711

Figure 2

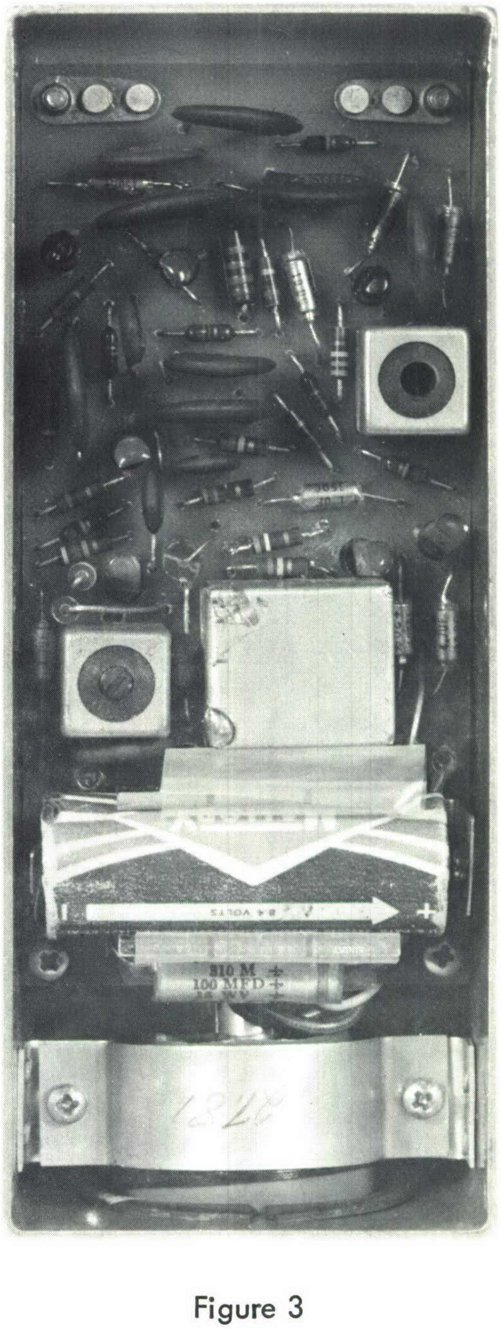
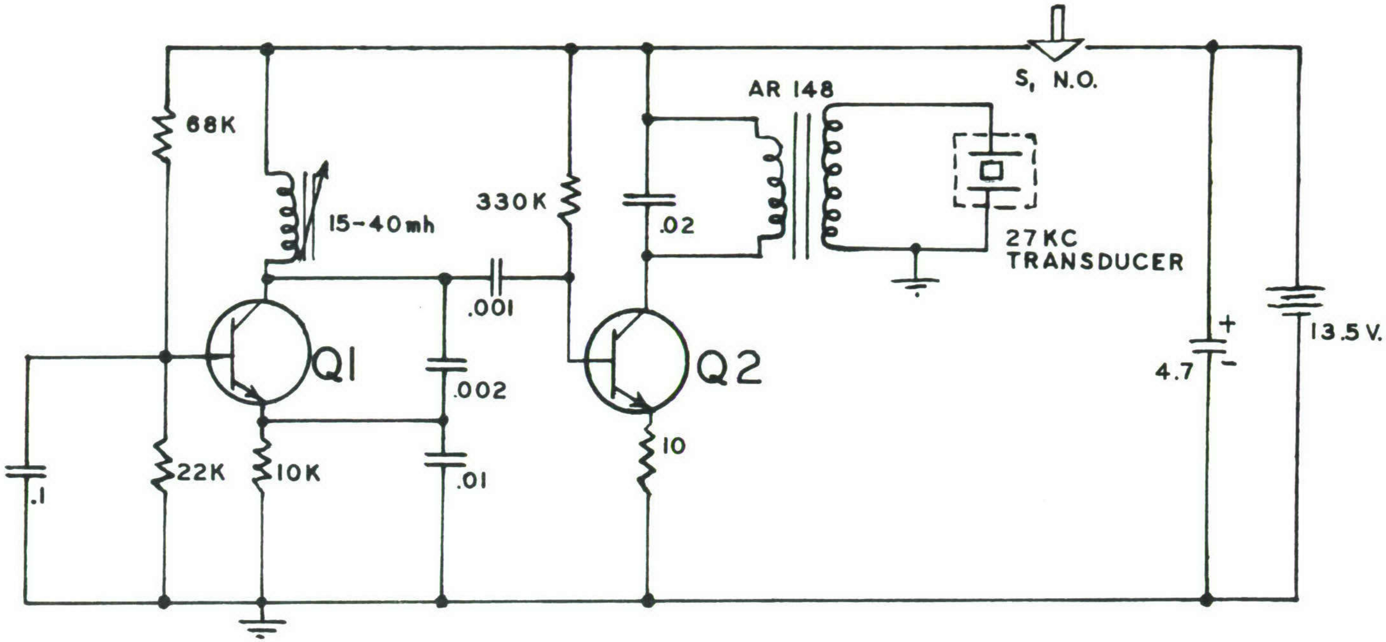


Figure 3



27 KC TRANSMITTER

NOTES

1. ALL RESISTOR VALUES IN OHMS
2. ALL CAPACITOR VALUES IN MICROFARADS
3. K = 1,000
4. mh = MILLIHENRIES
5. Q1 & Q2 ARE TYPE 2N2712

Figure 4

b. In a second-growth environment, woods and brush, 60 yards was attained with transmitter operator not visible in many instances.

c. Very dense vegetation, 20 yards.

It should be mentioned that the transmitted power was very moderate and a considerable increase should be attainable. Also operation was between waist and shoulder level for both transmitter and receiver. Published data shows that attenuation is decreased as the heights of the transmitter and receiver are increased.

Laboratory tests have established the sensitivity and acuity of the receiving units as being high enough to discerne a 0.2 microvolt signal at the input. The sensitivity rating of the 27 KC microphone is -54 d.b. relative to 1 volt per microbar. Therefore, an ultrasonic sound of one part in ten thousand of a microbar can be heard. (One microbar = 10^{-6} atmosphere.)

The current drain of the complete receiver is less than 2.5 milliamperes from an 8.4 volt battery.

The size and weights of the transmitter and receiver described here can be considerably reduced. Increased operational life, (if required) can be achieved with larger capacity batteries.

Range of propagation of ultrasound varies as the inverse square of frequency, all other conditions being constant. Also, most disturbances producing ultrasonic components generate more energy in the lower ultrasonic frequencies. Therefore, greater range in ultrasonic or "silent" detection and transmission (silent signalling) can be achieved by operating at a lower frequency while still remaining above the audible detection limit. For example, operation at 20,000 cycles per second as contrasted to 27,000 cycles per second will give an approximate doubling of effective receptive range, all other factors being equal, with the added bonus that more energy is naturally generated at the lower frequencies.

In the case of the transmitter, the peak power generated was very moderate. A considerable increase of signalling range can be achieved by developing more voltage and power across the sending microphone. Since the battery power is drawn only during "keying" of the transmitter, increased peak power output will not appreciably reduce the operational battery life of the transmitter.

Operation at lower ultrasonic frequencies should be considered to increase the detection range of ultrasonic signals. Lower frequency operation will also increase the range of transmission in the silent-signalling or communication mode.

II. CONCLUSION

Ultrasonic sensing is possible over limited ranges and ultrasonic (silent) signalling is possible in areas of heavy vegetation. Field tests will evaluate and establish the capabilities and areas of application of the described system.

APPENDIX

Circuit Description and Alignment:

The circuit configuration, Fig. 1, is similar to an ordinary superhetrodyne radio receiver. The transducer is equivalent to the antenna, and transistors Q_1, Q_2, Q_3 are analogous to an R.F. amplifier. The oscillator output and the amplified signal from the transducer are mixed at the base of Q_4. These signals combine in the mixer transistor Q_4 and a difference frequency (in the audible range) is produced at the collector of the mixer transistor. The difference output of the mixer has the basic "sound pattern" of the original ultrasonic signal intercepted by the transducer but has been translated to the audible range. This output is filtered to remove the local oscillator and ultrasonic components and is amplified by audio amplifier, transistors, Q_6 and Q_7. The resultant output of Q_7 is sent to an output transformer to provide a match to the listener's headset.

The alignment procedure for the unit is as follows:

a. The oscillator is disabled and a low capacitance oscilloscope probe is connected to the base of Q_3.

b. A variable frequency signal generator is coupled to an acoustic transmitter (in this case a "super-tweeter" is used as an ultrasonic transducer). The signal generator is "rocked" about the center frequency of the transducer and the input inductor is adjusted for a maximum output as indicated on the scope.

c. The oscillator is reactivated and adjusted to approximately 1,000 cycles away from center frequency by either utilizing a counter-chronograph to measure the oscillator frequency, or by applying a signal to the "super-tweeter" that is 1,000 cycles higher than the center frequency of the transducer and adjusting the oscillator tuning inductor for a zero-beat in the headphones.

(It is interesting to note that for this circuit configuration, hearing tests on many individuals showed a preference for the local oscillator to be set 1 KC <u>above</u> the center frequency of the input transducer.)

After the unit has been aligned, the user can make a few simple tests to gain a "feel" for the device. One can "listen-to"; the sounds of rubbing a hand across a shirt, jingling keys, the ticking of a watch, sniffing nasal sounds, running tap water, inaudible corona discharges, low pressure gas leaks, etc.

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